MULTI ROLL AND ALIGNMENT SYSTEM FOR DEEP ROLLING

This application claims the benefit of the filing date of United States Provisional Application Serial No. 60/411,602, filed September 18, 2002, and hereby incorporated by reference in its entirety

TECHNICAL FIELD

The present invention relates generally to tools for deep rolling, and more particularly to an apparatus having upper and lower tools with a connecting mechanism to align and stabilize the upper and lower tools relative to one another during a deep rolling process.

BACKGROUND OF THE INVENTION

Deep rolling apparatuses and deep rolling systems having been known for many years. The prior art deep rolling systems generally used a lower tool in conjunction with an upper tool to deep roll a crankshaft to increase the strength around lobes of a crankshaft for use in vehicles and other applications. A variety of upper tools and lower tools have been used in the prior art. The need for deep rolling is becoming ever more important because automotive vehicles and components thereof are being down sized to reduce weight and improve fuel efficiency, hence smaller engines and crankshafts are needed. With these smaller engines and crankshafts there is a need to improve the fatigue strength and durability of the smaller down sized crankshafts. This improved fatigue strength and durability is accomplished by deep rolling of the fillets or lobes and other circular joint areas on the crankshaft. The strength and durability of crank pins of the main bearing journals can be significantly increased by deep rolling compressive stresses into the middle of the annular fillets between the pin journals and the adjacent counter weights or balancing webs.

Some of the prior art lower tools use a system of rollers to support and roll the crankshaft while the upper tool uses work rolls to actually do the strengthening and finishing of the work pieces such as camshafts and crankshafts. Other types of lower work roll tools include a housing and side plate which hold and locate back up rollers and shafts. The back up rollers will operate to rotate a work roll which is held in place by a cage retainer and cage. The work roll will roll along the lobes and other fillets of a crankshaft to deep roll compressive stresses into such areas. The lower work rolls will work in unison with work rolls on an upper tool. Generally, the prior art deep rolling tolls included a single point work roll in an upper tool and two three point work rolls in the lower unit.

In the prior art the upper and lower tools were separate and distinct from each other and were capable of travel or "walking" relative to each other in an axial direction along the crankshaft being deep rolled. Furthermore, the fewer work rolls working the unit the longer it takes to deep roll the compressive stresses into the crankshaft, thus increasing the cost and time of the deep rolling process.

Therefore, there is a need in the art for a low cost integrated connecting mechanism to align and stabilize a lower tool with respect to an upper tool during the deep rolling process.

Furthermore, there is a need in the art for a four-point work roll mechanism to increase the speed and precision of the compressive stresses deep rolled into a crankshaft.

One object of the present invention is to provide a novel design for an alignment mechanism between an upper and lower tool for a deep rolling apparatus.

Another object of the present invention is to provide a design of a novel four-point work roll mechanism for a deep rolling apparatus.

Still another object of the present invention is to provide a design of a deep rolling tool that includes two sets of work rolls on an upper tool and two sets of work rolls on a lower tool to increase the speed and efficiency of the deep rolling process.

Other objects, features and advantages of the present invention will become apparent from the subsequent description, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a side view of an upper and lower tool connecting mechanism according to the present invention;

Figure 2 shows a side view of an alternate embodiment of a connecting mechanism to connect an upper tool and lower tool of a deep rolling apparatus;

Figure 3 shows a side view of a four-point work roll set up for use in a deep rolling apparatus.

SUMMARY OF THE PRESENT INVENTION

According to the present invention, the foregoing and other objects and advantages are attained by novel designs for an upper and lower work tool for a deep rolling tool apparatus. The upper tool would include an appendage extending from an end thereof. The lower tool would include a slot or channel in an end thereof adjacent to the upper tool. The appendage and slot would mate with one another to secure the upper tool to the lower tool with respect to a common shared plane. The deep rolling tool apparatus also could include a novel four-point work roll setup. The upper tool would include a plurality of work rolls while the lower tool will also include a plurality of work rolls. In one embodiment four work rolls would be included with both the upper and lower tool thus giving the four-point work roll deep rolling apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT AND BEST MODE OF CARRYING OUT THE INVENTION

Figure 1 and Figure 2 show one of many designs known for a lower work tool and an upper work tool for use in a deep rolling machine according to the present invention. It should be noted this invention can be used with any of the known lower tool designs and upper tool designs and any known deep rolling process apparatuses. The lower work tool 10 includes a main body 12 generally forming a rectangular shape with a cutout 14 on one side thereof. It should also be noted that a generally L-shaped main body might also be used in a separate embodiment contemplated for a lower work tool, or any other general shape that is capable of holding and rolling a cam shaft, crankshaft or the like. The main body 12 includes a housing and a side plate connected to one another, via any known fasteners, each having ports 16 therein to allow for lubrication during operation and easier cleaning of the lower tool mechanism 10 during operation thereof. It should be noted that any other number or set of slots, or even none may be used depending on the lubrication requirements and the design environment of the deep rolling tools. A first and second shaft 18, 20 are supported between the housing and side plate. A first and second backup roller are rotatably supported around the first and second shaft 18, 20 respectively. A bearing 26 is located between the backup roller 22, 24 and an inner race 28 for each backup roll. The inner race 28 will contact the shaft 18, 20 during rotation of the backup rolls. A first and second cage retainer 30, 32 are connected to an outer surface of the V-shaped cutout in the lower tool main body 10. A dual cage retainer 34 is located at the bottom portion of the V-shaped or other shaped notch in the lower tool 10 and is used to align the cage 36 in a necessary position.

A first and second work roll 38, 40 are located at four separate locations and held in place in the lower tool by the cages 36. The work rolls 38, 40 will contact the backup roller 22, 24 on

one side thereof and on an opposite side thereof will contact the work piece 42 being rolled. Therefore, the backup rolls 22, 24 in the lower tool will rotate at the speed with which the crankshaft or work piece 42 is being rotated.

The upper tool 44 will include a body member 46 that includes a housing and side plate, or in another embodiment or two-piece housing tool, each having porting 48 such as that described above for lubricating and cleaning of the upper tool 44. The upper tool 44 will include a shaft 50 and a backup roll 52 arranged around the shaft. It should be noted that it is contemplated to have a plurality of backup rolls and shafts within an upper tool mechanism also. The upper tool 44 will include a cage retainer 54 and a cage 56 on one end thereof, wherein the cage 56 will hold up to two work rolls 58 which will contact the work piece being rolled and the backup roll 52 on an outer surface thereof. The backup roll 52 includes an inner race 60 and a bearing 62, as described in the lower tool.

The upper tool 44 will include an appendage or male member 64 extending from a side adjacent to the edge or side having the work roll 58 thereon. The male member or appendage 64, as shown in Figure 1, can have a generally L-shape. The appendage 54 will be made of a similar material or different material to that of the upper tool 44 and will either be mechanically, chemically, magnetically or electronically connected to either the side plate or the housing or one end of either or both parts of the upper tool 44. One embodiment contemplates welding the appendage 64 thereon, another embodiment contemplates securing the male member 64 thereon via a fastener, another embodiment contemplates molding, forming, casting, brazing, gluing, epoxying, or any other known chemical bonding method.

It should be noted that the shape of the appendage 64 may also be varied from the generally L-shaped configuration shown in Figure 1. The appendage also has a predetermined

width and will extend a predetermined distance from the side of the upper tool 44 such that it will mate with and inter-engage with a like receptacle 66 in the lower tool. Therefore, any shape appendage 64 may be used depending on the environmental engineering and manufacturing requirements of the deep roll mechanism in the manufacturing environment. It is also contemplated to have the appendage made of a different material such as a hard ceramic, plastic, or any metal known.

The lower tool 10 will include a slot or channel 66 that will be used to receive and hold the appendage or male member 64 in a similar plane with respect to the lower tool 10. This will ensure that the upper and lower tool 10, 44 do not exhibit any axial movement relative to each other along the work piece 42 being worked. The receptacle or female member 66 will be connected to or arranged on an upper surface of either the side plate or housing of the lower tool 10 directly adjacent to the side of the upper tool 44 having the appendage 64. The female member 66 will be made of the same or a like material or any other material as noted above and connected by any known means including mechanical, chemical, any fastener, welding, casting, molding, forming, or other type of connecting means known. The slot 66 will be such that the width of the slot will mimic the width of the appendage 64 thus allowing for easy insertion and removal of the appendage 64 into the slot 66 while still allowing for radial movement between the upper tool 44 and lower tool 10. The appendage 64 and slot 66 may also include a locking mechanism therebetween. The male and female connections will restrict or eliminate any axial movement between the tools, thus keeping them from walking along the work piece 42 being rolled, thus increasing the efficiency and proper alignment of the stresses being rolled into the shafts. The use of the male and female member will allow the upper and lower tool to remain on a similar parallel plane while also allowing for any necessary radial movement between the tools.

Figure 2 shows an alternate embodiment of the mechanism to keep the upper 44 and lower tool 10 on the same parallel plane. In this embodiment an appendage 64 extends from both sides of the upper tool 44. Each appendage 64 would have an orifice 70 therein where a fastener 72 would be inserted. The lower tool 10 would include an orifice 74 on a top end thereof that mimics the shape of the end of the fastener 72 used in the upper tool 44. The orifice 74 would be molded, cast, formed, etc., directly within the lower tool 10 prior to manufacture of the lower tool or may be added as a secondary process via drilling or other boring techniques. In operation the upper tool 44 would have the appendage 64 on either or both sides and a fastener 72 would be placed either directly into the appendage 64 or an orifice would be placed in the appendage 64 and the fastener 72 would be placed therein. The fastener would then have its free end placed into the orifice or female slot 74 of the lower tool 10 thus allowing for the upper and lower tool to remain on a parallel plane while allowing for radial movement between the upper and lower tool for any necessary variances in the radius of the work piece 42 being rolled. It should be noted that Figure 2 shows the fastener 72 only on one side but it is contemplated to have a fastener 72 or pin on both sides of the upper and lower tool such that the plane will be similarly maintained through the entire work rolling process. It should be noted that any type of fastener, pin, shovel, rod, etc may be used to connect the upper tool 44 to the lower tool 44 to ensure the same plane in the axial direction. Alternative embodiments are contemplated (not shown) wherein the appendage is attached to the lower tool, and is received in a slot or channel in the upper tool. Further embodiments (not shown) are also contemplated wherein each of the upper and lower tools includes an appendage.

Figure 3 shows a novel four-point work rolling mechanism 100 for a deep rolling process. The four-point mechanism 100 would include an upper tool 102 and lower tool 104

which are generally set up as those described above and further detail will not therefore be given. The lower tool 104 and upper tool 102 will each include a body 106, 108 having a first 110, 112 and second backup roll 114, 116 in both the upper 102 and lower tool 104 respectively. The upper 106 and lower body 108 will also include a notch 118, 120 on one side of the body thereof. Within this notch 118, 120 will be located a first 122, 124 and second cage 126, 128. The first 122, 124 and second cage 126, 128 will hold the first 130, 132 and second work roller 134, 136 for each individual cage for each upper 102 and lower tool 104. Therefore up to eight work rolls can be used to roll the work piece 138 in the deep rolling process. Four work rolls will be located in the upper tool 102 and four work rolls will be locate in the lower tool 104. Each of the work rolls 130, 132, 134, 136 will contact the backup roll on one side thereof and on the opposite side thereof the work piece 138 being rolled. It is also contemplated to just having four work rolls, i.e. one in each cage, but always having the four-point work rolling system for the upper and lower tool in the deep rolling process. It should be noted that it is also contemplated to include up to six or eight point work rolling mechanisms in the contemplated invention by increasing the number of work rolls contacting the known backup rolls or even adding further backup rolls into the upper and lower tools without affecting the weight, cost or size of the deep rolling mechanisms. It should be noted that it is contemplated to make the four-point work rolling system out of any of the known materials for current work rolling mechanisms such as aluminum, metal or any other type of hardened composites, plastics or metal material.

While it may be apparent that the preferred embodiments of the invention disclosed are well calculated to fill benefits, objects or advantages of the invention, it will be appreciated that the embodiments disclosed herein are susceptible of modification, and the present description should not be understood to limit the scope of the invention in any manner. Thus, those skilled

in the art will appreciated that various alterations might be made to the presently disclosed embodiments without departing from the spirit and scope of the present invention.